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Velocity Stage Turbines

DE LAVAL STEAM TURBINE CO.
TRENTON, NEW JERSEY

DE LAVAL

Velocity Stage

STEAM TURBINES

DE LAVAL STEAM TURBINE CO.

TRENTON, NEW JERSEY

LOCAL OFFICES: Atlanta, Boston, Charlotte, Chicago, Cleveland, Denver, Duluth,
Helena, Houston, Havana, Indianapolis, Kansas City, Los Angeles,
Montreal, New Orleans, New York, Philadelphia, Pittsburgh,
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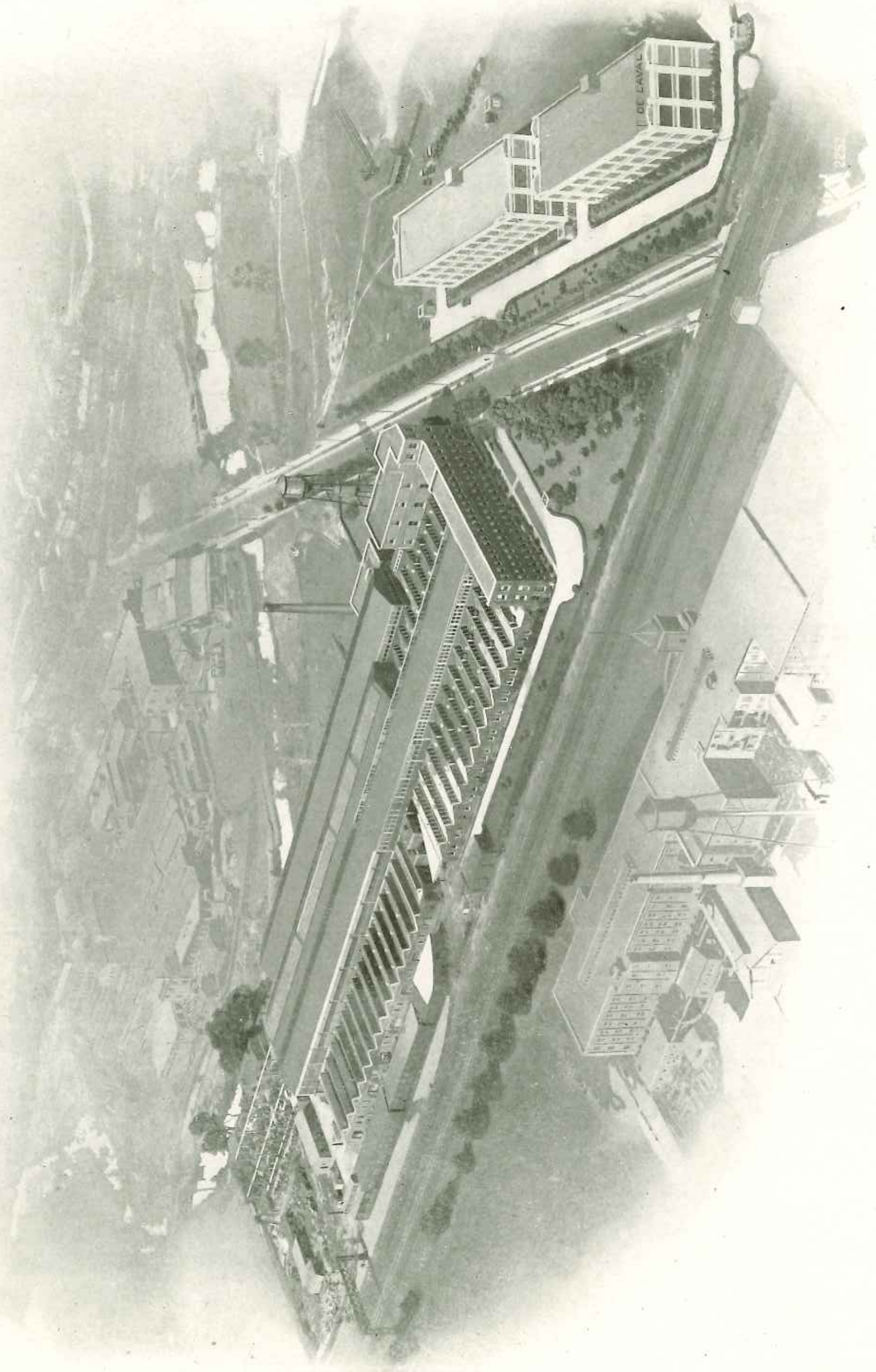
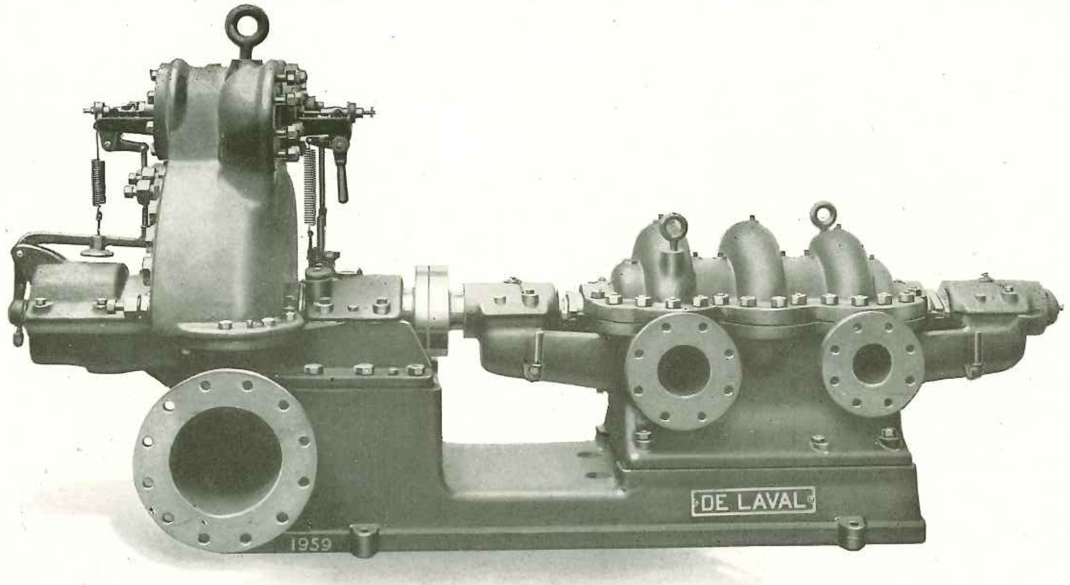


Works and Main Offices of the De Laval Steam Turbine Co., Trenton, N. J.



Velocity stage turbine driving three stage De Laval double suction series pump

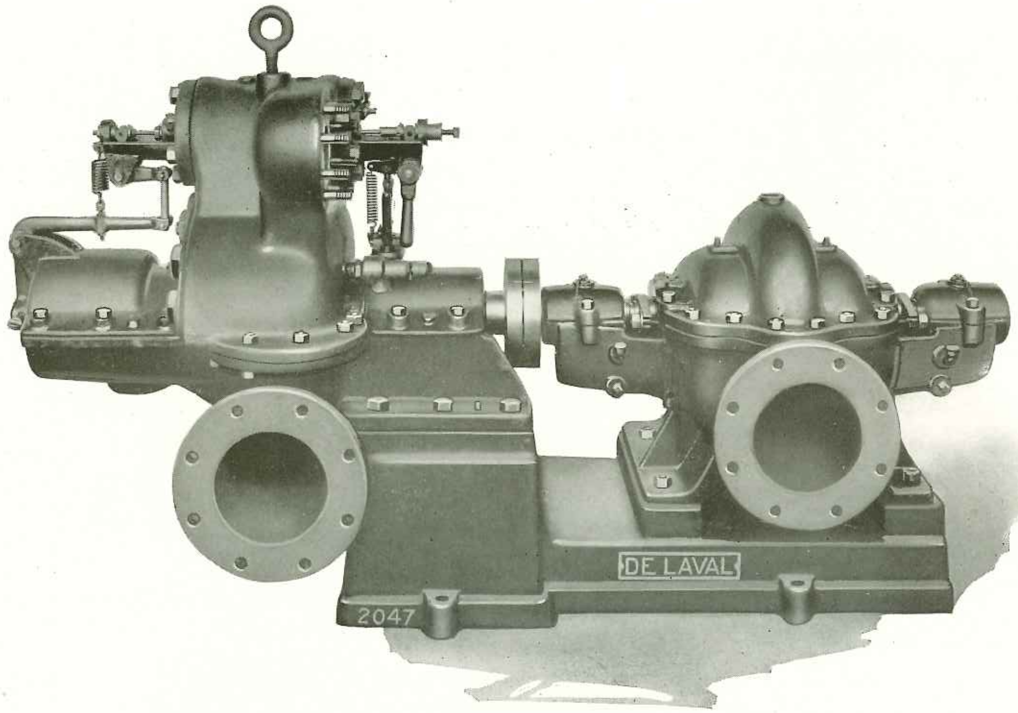
SMALL TURBINES

FOR MODERN STEAM CONDITIONS

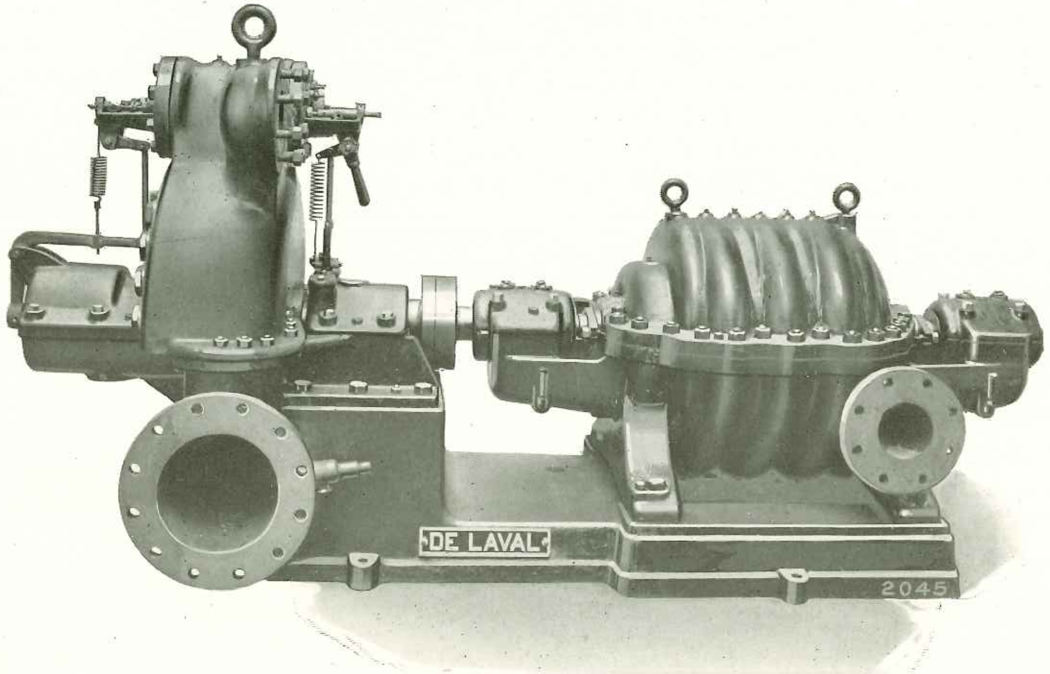
THE line of steam turbines described in this bulletin has been designed to meet modern requirements and conditions as to steam pressure and superheat. The standard line of turbines is designed for pressures up to 400 lb. gage and for temperatures up to 725° F. Special designs can be furnished for higher pressures and temperatures.

Small turbines ordinarily receive, and should demand, but little attention. In the De Laval Velocity Stage Turbine low bucket speed, ample clearances, both axially and radially, high grade materials and workmanship and liberal design insure reliability and long life. The turbine is rigidly supported near the center line, permitting expansion of the wheel case in all directions without disturbing the alignment. High temperature, high pressure steam is confined to the upper part of the turbine casing, thus eliminating cross over steam connections and the necessity of water cooling the bearings, except for extreme conditions of temperatures. Separate governors control the independent speed control and emergency cut out valves. All parts are readily accessible, and are built to limit gages on an interchangeable basis, so that replacement of parts subject to wear, such as buckets and bearings, can be made by ordinary, unskilled workmen.

At the same time, within the limitations imposed by capacity and steam conditions, the efficiency is as high as is possible for a single pressure stage turbine. The steam used develops the maximum amount of work, which is always desirable even though the exhaust be subsequently utilized in feed water heaters, in heating and drying systems, or in industrial processes.



Velocity stage turbine driving De Laval single stage centrifugal pump



Velocity stage turbine driving De Laval multistage centrifugal pump

THE DE LAVAL VELOCITY STAGE TURBINE

THE De Laval Velocity Stage Impulse Turbine is equipped with one wheel, which carries two rows of buckets, an intermediate set of stationary guide vanes redirecting the steam from the first row of buckets upon the second row. The clearances between the stationary nozzles and vanes and the revolving bucket are large.

The steam is expanded to exhaust pressure in the nozzles before it strikes the buckets. The wheel revolves in steam at exhaust pressure, and as the pressure is the same on both sides of the wheel, there is no appreciable axial thrust.

The turbine casing is supported on a single pedestal, close to the center line of the machine, in order to avoid constraint and misalignment due to changes in temperature.

Details of design are illustrated and described on pages ten and eleven of this leaflet. Attention is, however, directed particularly to the following outstanding characteristics:

1. RUGGED CONSTRUCTION—All parts are of liberal size and the revolving elements are so proportioned as to avoid high stresses in buckets and wheel. Ample bearing brackets and shaft insure smoothness in operation, under the most severe conditions.

2. MATERIALS—Careful selection has been made of materials found, through years of experience, to be most suitable for this class of turbine. Hammer forged steel is used for shafts, forged steel for wheels, and nickel steel for buckets. The steam chest and valve casing are made of cast steel for high steam pressures and temperatures.

3. METHOD OF MANUFACTURE—All parts of the De Laval Velocity Stage Turbine are manufactured with the assistance of special jigs, gages and fixtures, in order to insure interchangeability. Parts are manufactured in quantities and are carefully inspected, using limit gages, which eliminates hand fitting when assembling the machine. This method of production insures that the customer will receive interchangeable parts if repairs are ordered.

4. THE TURBINE CASING—The turbine casing consists of the casing proper and the cover. The horizontal joint between the two parts is in the plane of the center line of the shaft. This joint is subjected to steam at exhaust pressure only.

5. STEAM CHEST AND VALVE BODIES—The casing cover, the steam chest, and the steam inlet nozzle, together with the emergency closing valve and regulating valve bodies, are all cast integral in one piece, thus eliminating joints which would be subjected to high pressure steam. This arrangement also reduces the amount of exposed surface from which heat may radiate, and avoids excessive temperatures around or near the bearing housings. Since the steam chest is wholly contained in the casing cover, no cross over connection to the lower part of the casing is necessary. A removable steam strainer is incorporated in the inlet valve housing.

6. BEARINGS—The turbine shaft is supported in two liberally proportioned, babbitt lined bearings. The bearings are lubricated by means of rings which carry oil from reservoirs below the bearings. The bearing brackets, being cast integral with the exhaust chamber of the casing, are not subjected to direct heat by radiation nor by conduction of heat from the steam chest, which is located in the upper half of the casing. This prevents excessive heating of the bearing

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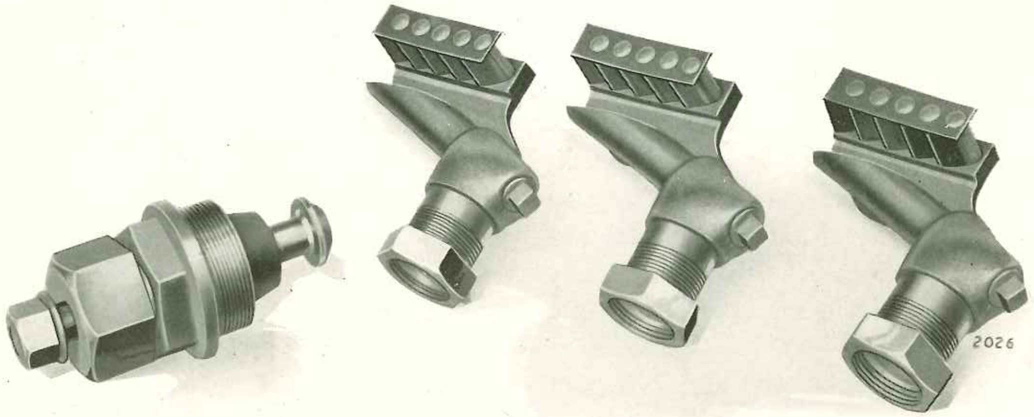
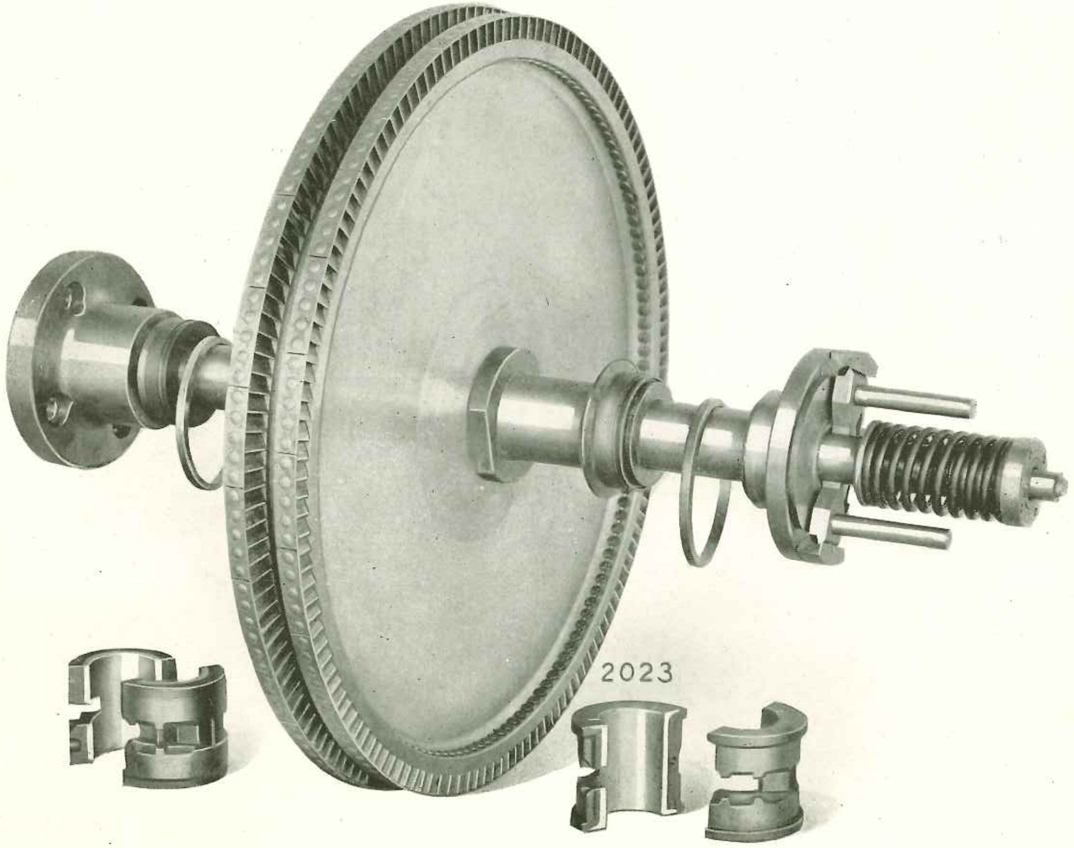
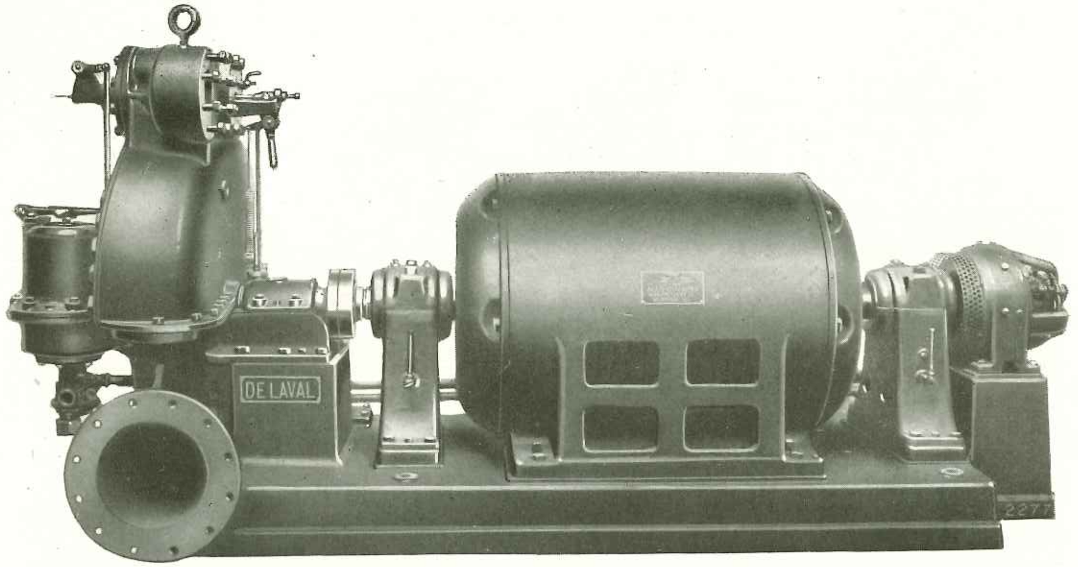


Nozzles, with attached interstage guide vanes, also nozzle control valve



Wheel, shaft, governor, driving half of coupling, and bearings



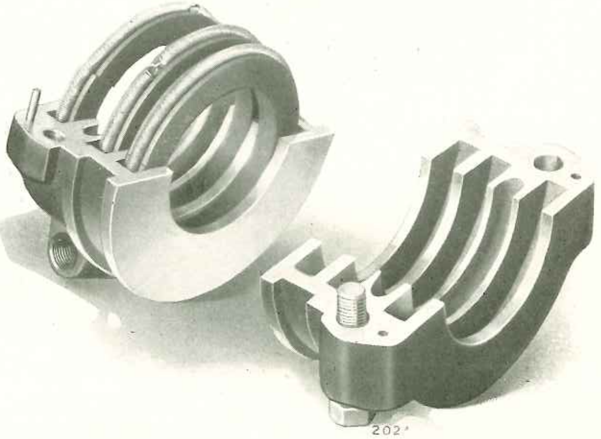
Velocity stage turbine with vertical shaft governor driving 200 kw. alternator

oil and eliminates any need for water cooling of the bearings, except for unusual operating conditions.

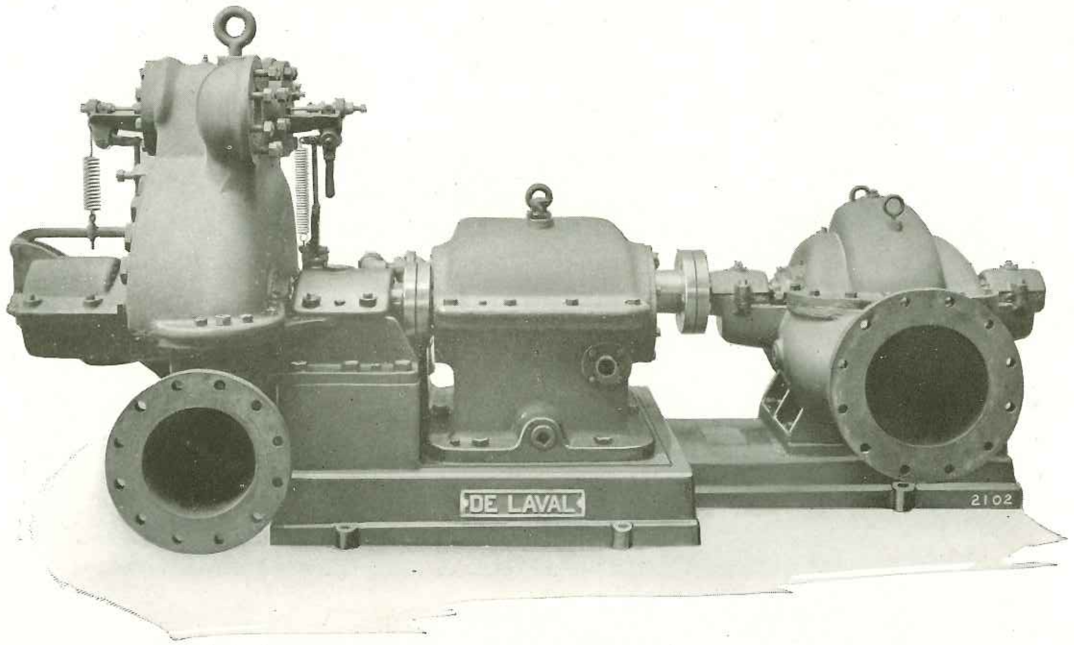
7. NOZZLES—The nozzles are machined in separate castings, which are individually held in position by the steam chest. Each nozzle casting supports the corresponding guide vanes in proper position. This design provides great flexibility in adapting the turbine to changed steam conditions or power requirements. Individual nozzles can be provided with hand operated shut-off valves, which can be closed or opened to suit operating conditions, thus making possible good steam economy over a wide variation of load or steam pressure.

8. THE SPEED REGULATING VALVE is of the balanced piston type and operates in a valve housing cast integrally with the steam chest. The valve rod is made of monel metal to prevent erosion or rusting, which might cause the valve to stick. The valve, being located in the top part of the casing cover, is easily accessible. The valve seat is removable.

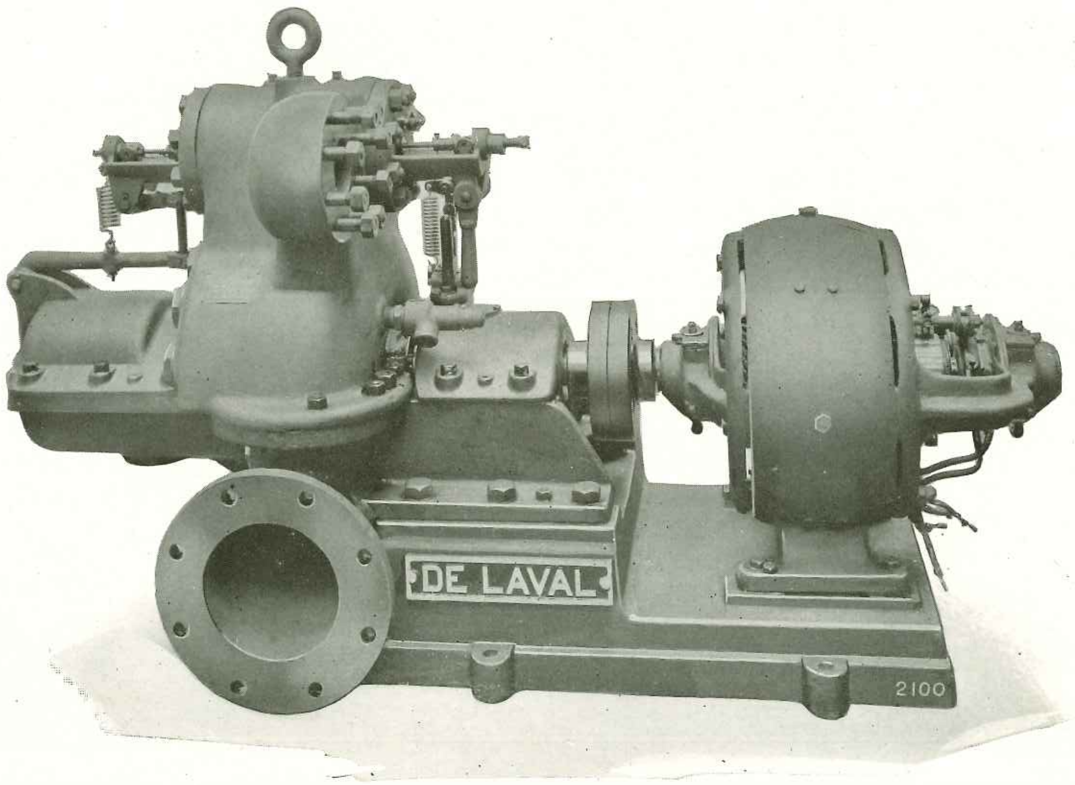
9. THE EMERGENCY SHUT-OFF VALVE is located directly opposite the regulating valve. This valve is single seated and is mounted on a monel metal spindle. It is closed by a spring released by the functioning of the over-speed governor. The accessibility of the emergency valve makes it easy for the attendants to keep the valve at all times in good operating condition, which is essential if it is to function properly. The valve seat is removable.



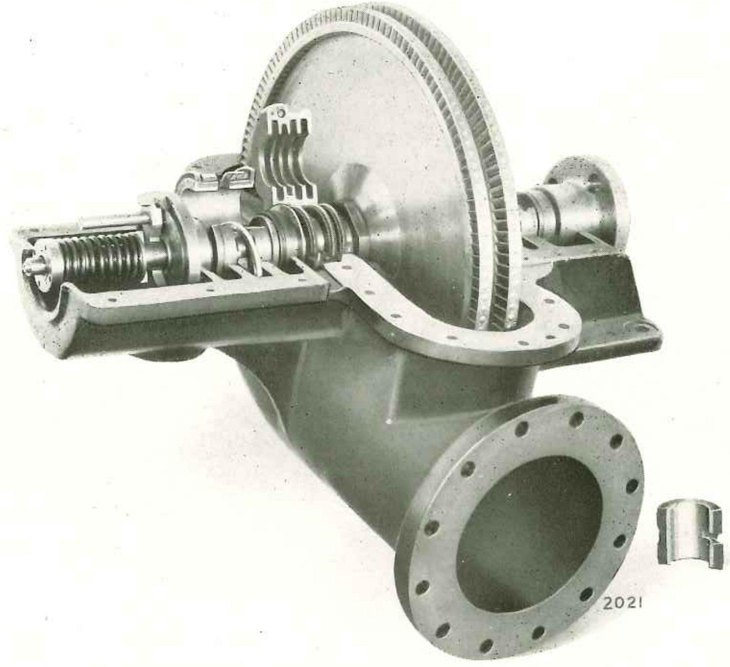
Shaft packing gland, with carbon ring packings



Velocity stage turbine driving centrifugal pump through speed reducing gear



Velocity stage turbine coupled to direct current generator



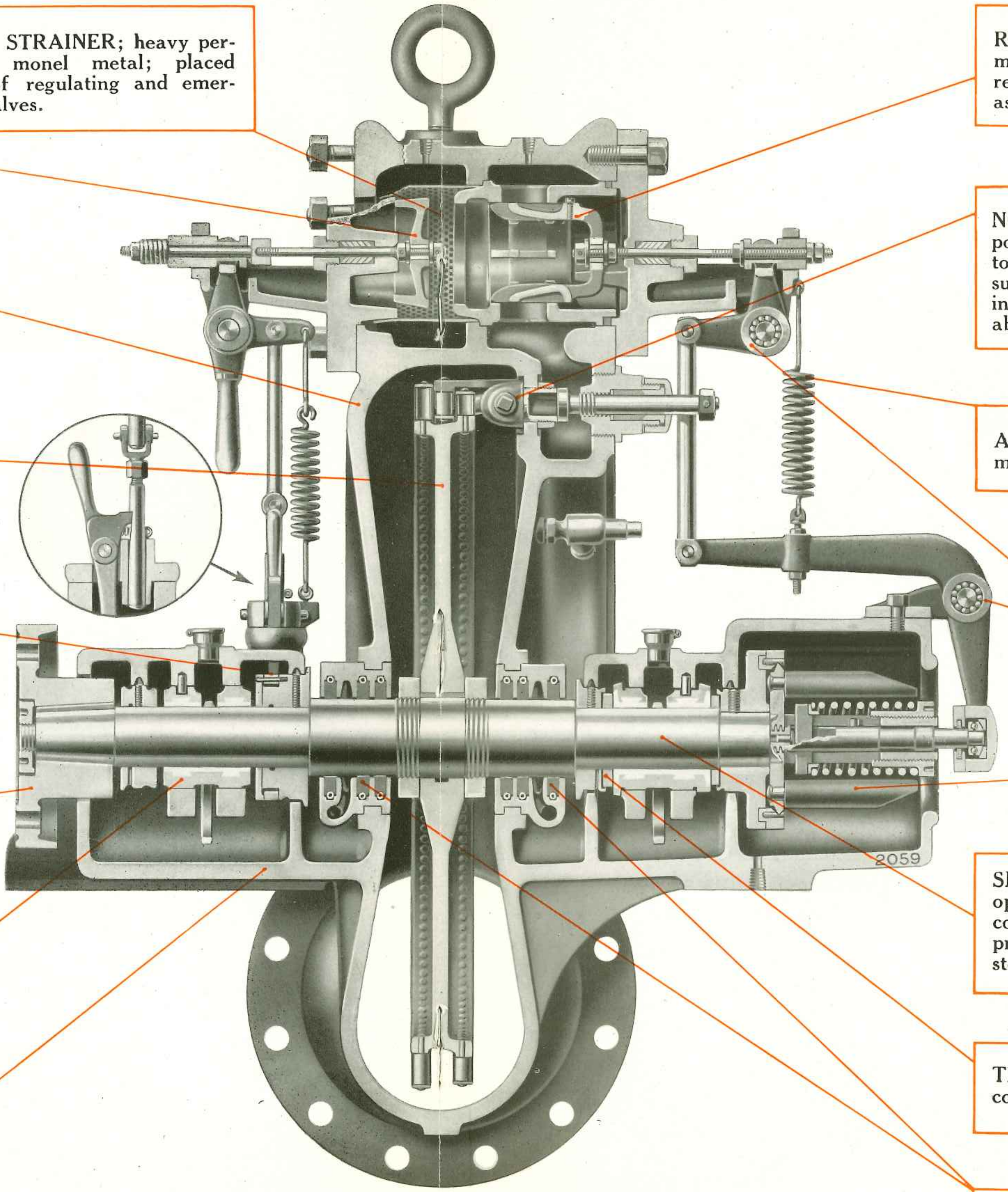
Velocity stage turbine with upper half of casing, including steam chest and governor valves, removed, showing wheel and buckets, carbon ring shaft packings, ring oiled bearings, and speed governor

10. SPEED AND EMERGENCY GOVERNORS—Every De Laval turbine is provided with two methods of speed control. The speed governor, which actuates the regulating valve, is of the centrifugal type, the weights with their supporting arms working on knife edges. The movement of the governor weights is transmitted to the regulating valve levers through a ball bearing. All governor levers are supported on roller bearings to reduce friction. If necessary, provision can be made for varying the speed of the turbine while in operation.

The emergency governor consists of an unbalanced ring pivoted on a collar on the shaft close to the inner turbine bearing and held in position by a small spring. This emergency governor comes into action at a speed 10% higher than does the speed regulating governor, and releases the emergency closing valve.

Where the turbine drives a boiler feed pump, a pressure regulating governor can be attached to the casing cover for regulating the speed of the turbine to suit the pumping conditions. This pressure regulating governor can be attached without removing the regular speed governor.

In *the De Laval velocity stage turbine for speeds above 3,600 r.p.m.,* illustrated on pages 7, 13 and 14, and used principally in connection with reduction gears and blowers, the speed governor, for mechanical reasons, is mounted on a vertical shaft driven from the turbine shaft through a worm and worm wheel. The high speed turbine is also provided with an oil pump for forced feed lubrication. All other details are practically the same as in the lower speed turbines, although in certain sizes smaller diameter wheels are used, as permitted by the higher speeds. The use of small wheels at a greater number of revolutions per minute is favorable to higher efficiency, due to reduction in disk friction.



EMERGENCY CLOSING VALVE; single seating, separate from speed governor valve; valve spindle monel metal; valve seat removable.

WHEEL CASE COVER; entire cover made of steel for high pressures and temperatures; cast integral with inlet nozzle, valve body and steam chest, eliminating packed joints; no cross over connections to lower half. High pressures and temperatures confined to parts of turbine above the center line, far removed from bearing brackets and oil reservoirs.

WHEEL; forged steel; accurately machined and balanced; held on shaft by key and lock nut; nickel steel buckets; large axial and radial bucket clearances.

EMERGENCY GOVERNOR; eccentrically loaded ring pivoted on collar; trips emergency closing valve at predetermined overspeed; also arranged for tripping by hand.

FLEXIBLE COUPLING; driving and driven flanges accurately turned and ground on face and periphery to facilitate lining up; steel lined rubber bushings on driving pins deaden shocks, provide flexibility and serve as electrical insulators; taper fit insures concentric mounting of coupling on shaft.

BEARINGS; accurately machined, cast iron, babbitt lined bearing shells ground to fit accurately scraped seats in bearing housings, which are cast integral with the turbine casing; copious lubrication provided by oil rings; water cooling unnecessary.

TURBINE CASING; rigidly supported near center line by single heavy pedestal, so that casing can expand in all directions without affecting the alignment of the shaft. Seatings for bearings and gland housings machined in one setting.

STEAM STRAINER; heavy perforated monel metal; placed ahead of regulating and emergency valves.

REGULATING VALVE; balanced piston type, mounted on monel metal spindle; operating in a removable valve cage; packing for valve spindles pure asbestos tapered rings, requiring no adjustment.

NOZZLES; machined in separate castings and supported by steam chest wall; orifices bored and reamed to exact contour; guide vanes integral with and supported by nozzles; hand valves provided for individual nozzles to maintain efficiency under variable load or steam pressure.

ADJUSTING SPRING; adjustments in speed can be made while machine is in operation.

ROLLER BEARINGS; reduce governor lever friction to minimum.

SPEED GOVERNOR; powerful and sensitive; weights pivoted on knife edges; governor action transmitted to bell crank through ball thrust bearing.

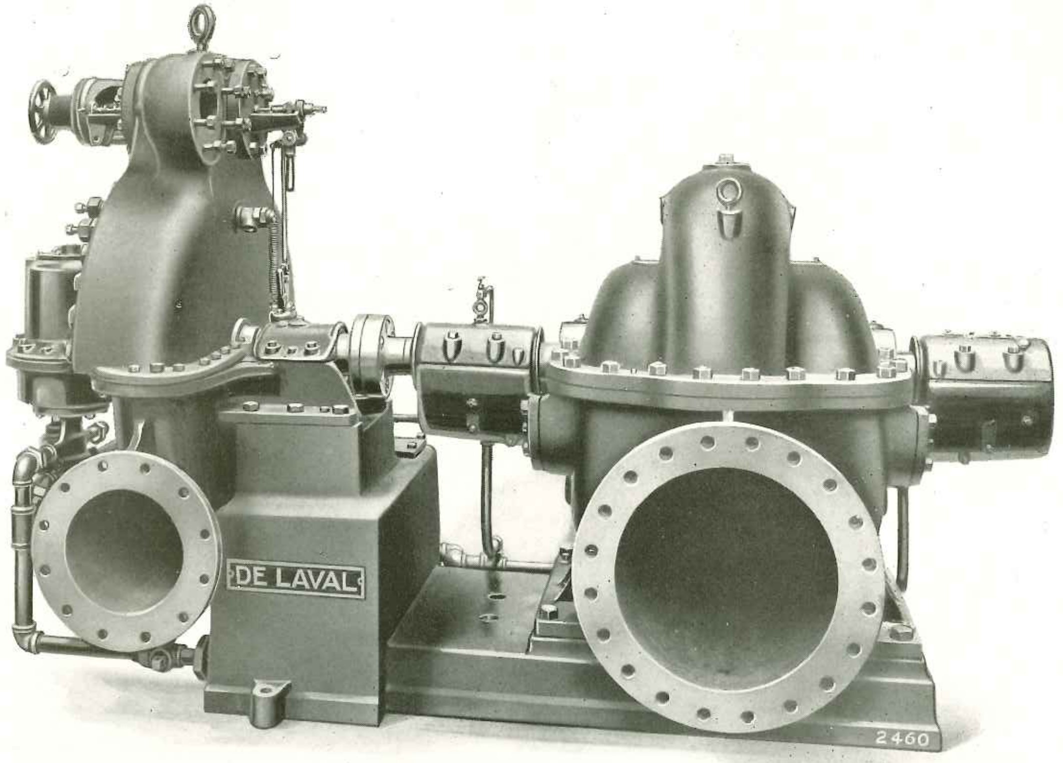
SHAFT; large and liberally designed, to give perfect operation under all running conditions; provided with collars to act as oil slingers and steam deflectors, preventing oil from creeping along the shaft and steam and moisture from entering the bearings.

THRUST BEARING; maintains turbine rotor in correct position and acts as oil slinger; easily adjusted.

SHAFT PACKING; carbon rings supported in accurately machined housings; can be arranged for steam sealing for condensing operation.

AXIAL SECTION OF DE LAVAL VELOCITY STAGE TURBINE.

Parts are manufactured to limit gages and are strictly interchangeable. Each part is stamped with symbols for identification and to certify inspection. All parts are accessible upon lifting the casing cover.



Velocity stage turbine with variable speed governor driving De Laval gas blower; 20,000 cu. ft. of free air per min. against 50 in. water column at 3,600 r.p.m. The turbine governor can be adjusted to vary the speed while the turbine is operating

11. SHAFT PACKING—Where the shaft passes through the walls of the casing, shaft packings are provided, each consisting of three carbon rings held in a separate housing. Should the turbine be operated condensing, sealing steam at a pressure above atmosphere can be admitted to the housings containing the carbon rings.

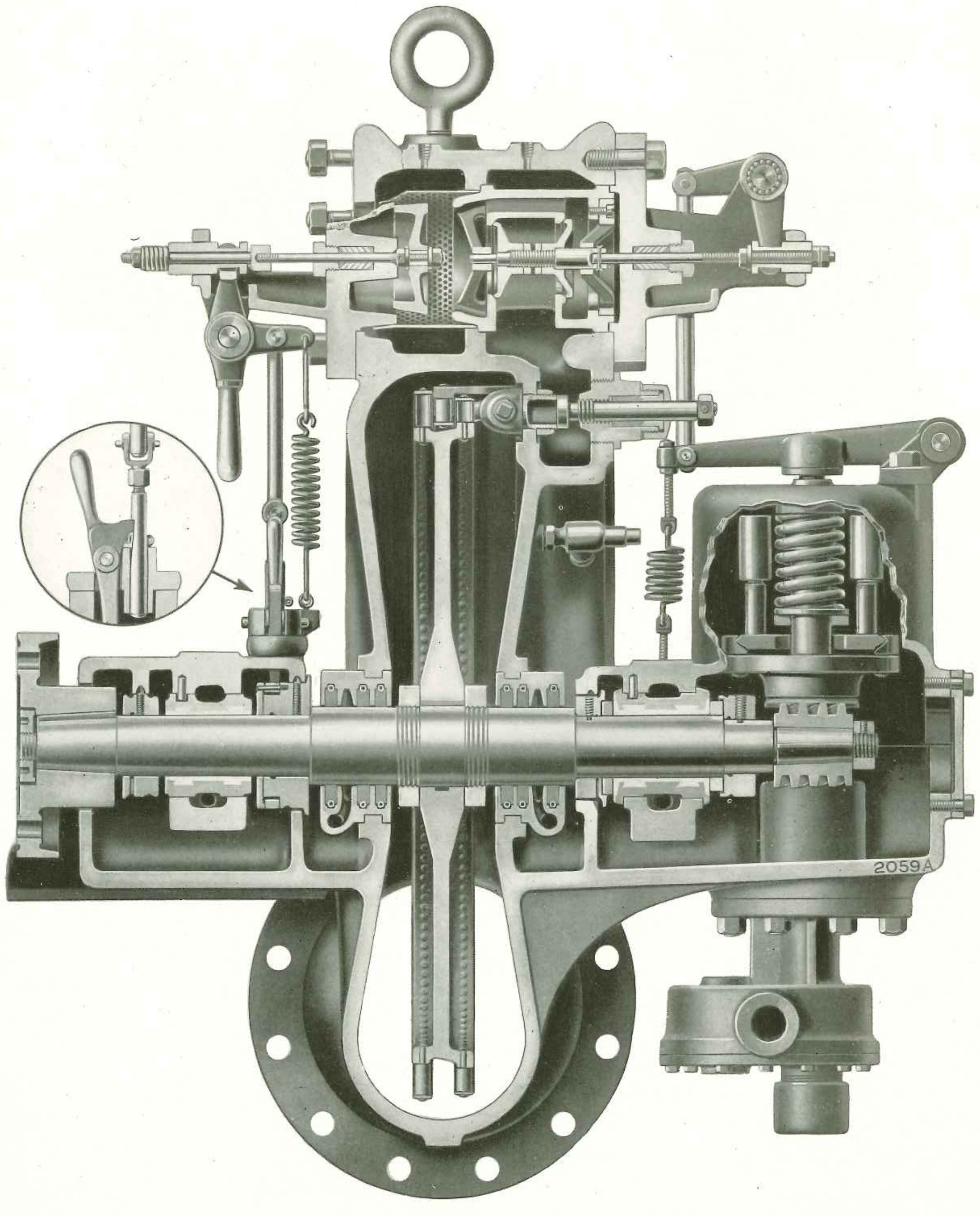
12. METHOD OF SUPPORT—The turbine casing is rigidly supported close to its center line by a heavy pedestal, in such manner that expansion and contraction of the wheel case due to temperature changes can take place in all directions without disturbing the alignment of the shaft.

13. A FLEXIBLE COUPLING, of the De Laval rubber bushing type, connects the turbine shaft to the shaft of the driven machine. This type of coupling allows free, independent movement of the shafts in an axial direction, and the rubber bushings compensate for any slight error in alignment. Couplings of special construction are used for geared drives.

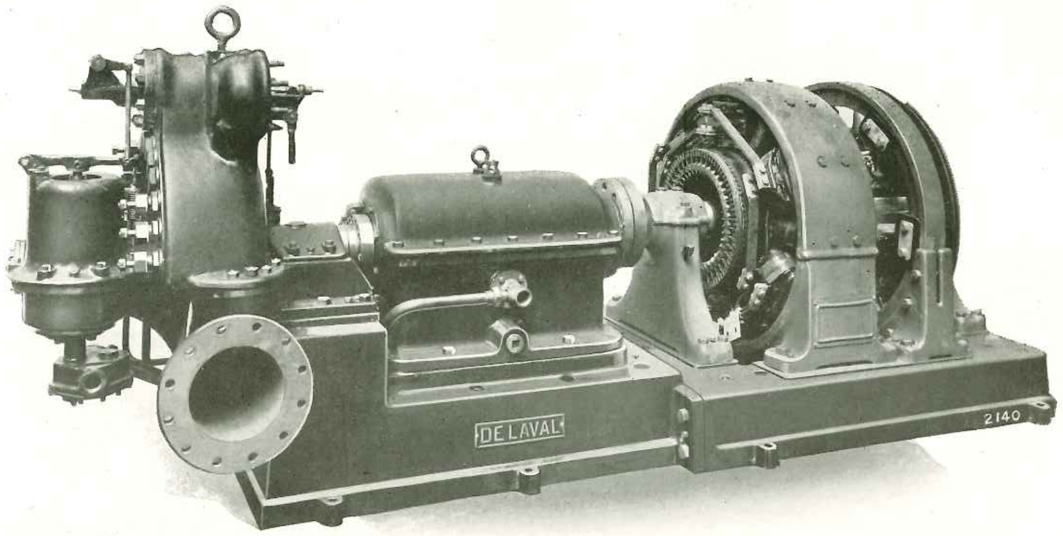
SIZES AND USES

The DeLaval Velocity Stage Turbine is built in sizes from 1 hp. to 800 hp., and is primarily designed for non condensing service. It is an ideal prime mover for any type of machinery that can be driven from a rotating shaft.

De Laval Velocity Stage Turbines can be directly connected to high and moderate speed machinery, such as small direct current generators and alternators, centrifugal boiler feed pumps, elevator pumps, service pumps, blowers and compressors.



Axial section of De Laval velocity stage turbine with vertical governor and oil pump



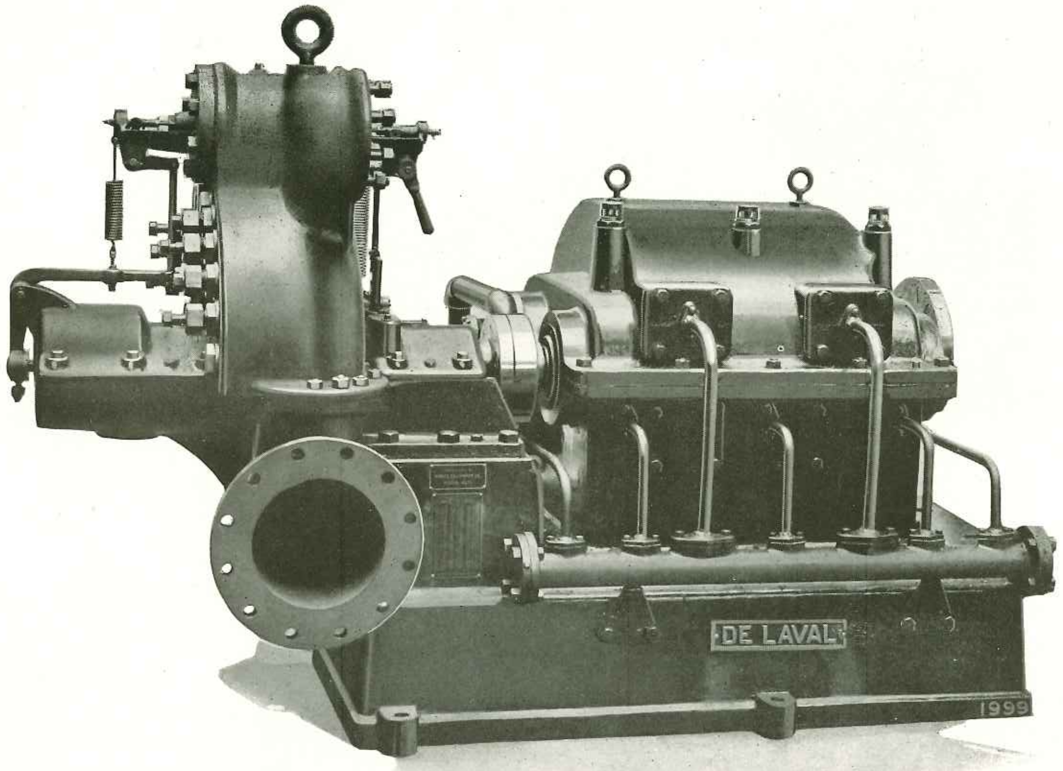
De Laval velocity stage turbine with vertical governor driving 200 kw. direct current generator through De Laval double helical speed reducing gear

Each complete De Laval turbine driven *centrifugal pumping unit*, consisting of velocity stage turbine and centrifugal pump mounted on a common base plate, is designed, built, sold and installed by one organization, which assumes undivided responsibility for guarantees and operating results.

The simplicity and ruggedness of the De Laval velocity stage turbine are particularly valuable in *blower and compressor units*, which are generally subjected to severe handling, with frequent speeding up and slowing down, as in gas house service, where blowers are often placed in unfavorable locations and receive little attention. A De Laval turbo blower, consisting of a velocity stage turbine directly connected to a De Laval blower, is designed to give the utmost dependability in continued operation.

Low speed machinery, such as medium size direct current generators and alternators, large or low head centrifugal pumps, low pressure fans, and belt pulleys, rope sheaves or shafting, are most efficiently driven through the medium of the De Laval Double Helical Speed Reducing Gear or of the De Laval Worm Reduction Gear, described in separate catalogs.

In some cases purchasers, who may be prejudiced against reduction gears, prefer to connect the turbine directly to a pump, even though the speeds may be such that the overall efficiency is appreciably less than that which could be obtained with a geared unit. The reliability and high efficiency of the De Laval reduction gear has, however, been fully established, and the reduction gear will operate just as satisfactorily as either the pump or the turbine, with the definite advantage of higher efficiency and longer life for both the turbine and the pump, or other driven machinery.



Velocity stage turbine mounted on base plate with double helical speed reducing gear; 3,600 and 450 r.p.m.

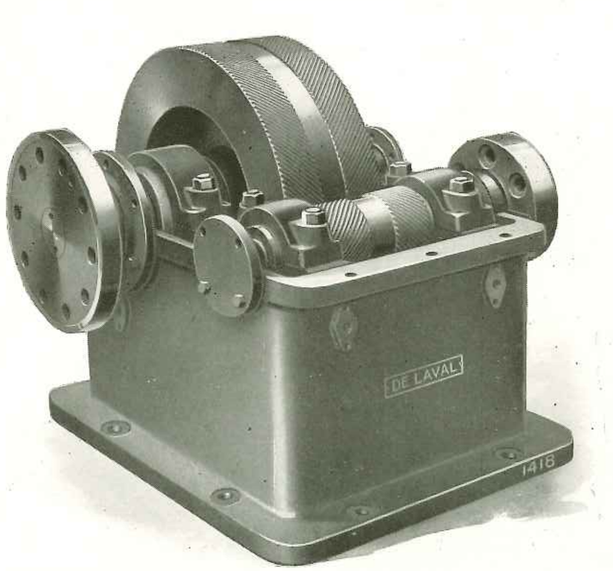
THE DE LAVAL DOUBLE HELICAL SPEED REDUCING GEAR

THE use of steam turbines of small and medium sizes has been greatly extended by the perfection of the double helical speed reducing gear.

This type of gear was first developed by Dr. De Laval and its present perfection, in respect both to design and to method of manufacture, has been realized in the De Laval Works. The inherent characteristics of the steam turbine require high speed in order to obtain high efficiency, and this high speed rarely coincides with the speed which is best for the driven machine. The double helical gear, however, offers a highly efficient and reliable means for connecting a high speed turbine to low speed machinery.

To meet successfully all requirements of high speed turbine service, double helical gears must conform to certain criteria, which, from the experience of the De Laval Steam Turbine Company in building such gears for more than twenty-five years, can be stated as follows:

1—The type of gear most suitable for turbine speeds in the great majority of applications is the helical or twisted gear, in which the transition of pressure from tooth to tooth is uniform and without shock or vibration.



Double helical speed reducing gear, two pinion bearings

2—Two helices of opposite angles are advisable in order that axial thrust may be balanced, and the angle of the helix should be such that several teeth are always in contact.

3—The cutting process must be such as always to give correct pitch, correct angle and correct tooth contour, as these cannot be corrected subsequently by hand operations. The pitch, angle and contour should be standardized, so that gears and pinions manufactured at different times will be interchangeable. High speed gears require much greater accuracy than can be obtained with commercial gear cutters, for which reason we have developed and built our own precision gear cutters.

4—The involute tooth is most suitable, as it gives true linear contact on each tooth.

5—The tooth pressure allowable has been determined by extensive experience and is limited principally by the diameter of the pinion and by the pitch velocity. It must permit of maintaining an unbroken oil film between the metal surfaces.

6—The teeth should be polished by mechanical means to remove scratches, tool marks, etc., but hand work, such as scraping, filing, etc., is not permissible, as it would destroy the correct tooth contour.

7—Gear and pinion must be adequately supported in a rigid gear casing. With proper tooth pressures and shapes and with proper pinion and gear supports, teeth will retain their original contours and the gear reduction will continue to operate quietly and without vibration.

CONSTRUCTION OF DE LAVAL GEARS

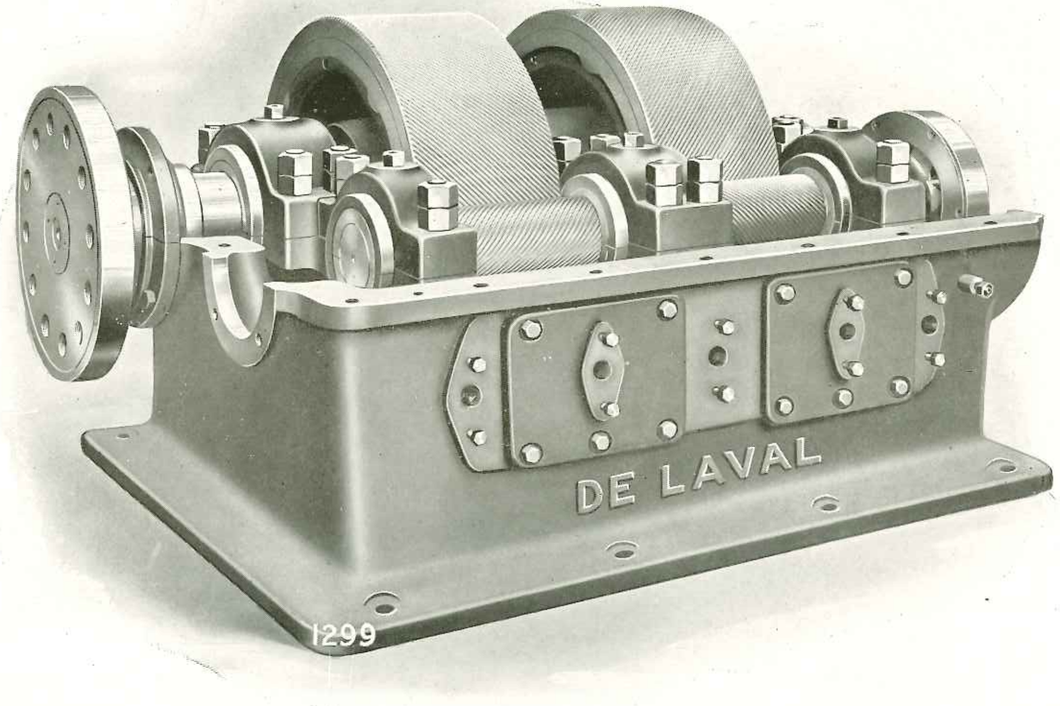
THE MAIN GEAR consists of a rigid cast iron center or hub, upon which are shrunk one or two seamless, rolled, steel bands, in which the teeth are cut.

The PINION is cut directly on the pinion shaft, which is a special nickel steel forging, so heat treated as to be much harder than the gear band, in order that the metals in contact may be of different qualities and of different degrees of hardness.

The GEAR CASE is a single casting, made very heavy and rugged, so that it may be free from springing, distortion and vibration and in order to maintain correct alignment of, and uniform pressure on, the teeth at all points.

The teeth of gear and pinion are lubricated by a spray of oil projected at the line of contact on the entering side. The oil drains to the bottom of the gear case and passes through a strainer to a positive, gear type pump driven from the gear shaft or from the turbine shaft.

The gear is supported by two BEARINGS, and the pinion is supported by two or three bearings, depending upon conditions. The bearing shells are ground to limit gages and the gear case bearing housings are carefully scraped to lining bars to insure parallelism of shafts and interchangeability. The bearing caps are entirely separate from the gear case cover, which completely encloses them. It is consequently not necessary to remove the bearing caps or to change their adjustment in order to remove or replace the cover. Oil leakage is also eliminated, as there are no joints between cover and bearing caps.



Double helical speed reducing gear with cover removed

Clean oil at all times is essential, and we recommend the overhead gravity tank system of lubrication, as in the event of failure of the oil pump, which is driven from the main unit, there will still be sufficient oil stored in the overhead tank to permit of operating until the auxiliary oil pump can be started. Also, impurities settle out in the overhead tank and can be drained from the tank without interrupting the operation of the oiling system.

FLEXIBLE COUPLINGS are used for connecting the pinion to the turbine shaft and for connecting the gear shaft to the shaft of the driven machine.

All parts of the reduction gear that can be disassembled for inspection are furnished with taper dowels to insure perfect alignment in reassembling. Working parts are made to standard limit gages and are interchangeable, and can be replaced quickly without requiring to be fitted and without the necessity of making measurements or of realignment.

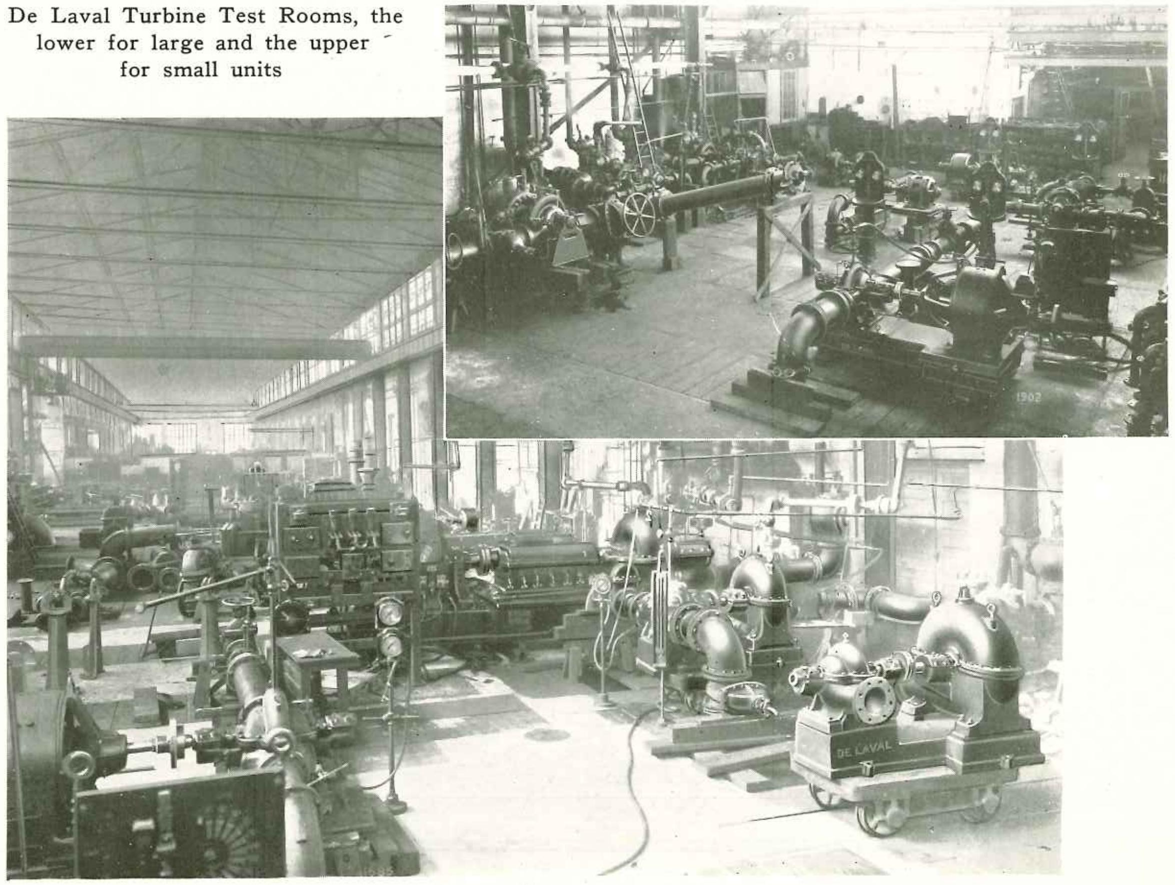
The high efficiency of De Laval gears is demonstrated both by their long life, many of them having been in continuous operation for over twenty-five years, and also by their low operating temperature. The efficiency of conversion is above 98%.

Conclusive proof of the correct design of De Laval gears and of the proper method of support is furnished by the almost entire absence of noise. Noisy gears are inefficient and wear out quickly.

TESTING

EACH turbine is tested before shipment from our Works. Accurate testing is usually not possible at the point of installation, but it is only by careful testing that the designer can check the results of his work, and that the purchaser can be assured that the apparatus will meet guarantees. Neglect of testing entails heavy loss on many owners, who continue to operate inefficient machines, when, were the truth known, it would pay to scrap them and to buy more efficient apparatus. The policy of uniform testing is also a protection against the tendency of turbine builders, under pressure of competition, to guarantee better results than can be produced. Complete service by the builder includes accurate testing. A test is necessary, not only to determine that the machine meets specifications, but also to insure satisfactory mechanical operation.

The testing plant of the De Laval Steam Turbine Company is equipped with surface condensers and means for accurately measuring the steam used. A complete set of dynamometers and a large number of special testing instruments, including water measuring devices for testing centrifugal pumps of all capacities, electrical measuring instruments, etc., are provided. The testing plant is operated as a separate department and is in charge of competent men who do nothing else but test equipment.


De Laval Turbine Test Rooms, the lower for large and the upper for small units

MANUFACTURING METHODS OF THE DE LAVAL STEAM TURBINE CO.

The organization and equipment of the De Laval Steam Turbine Co. have been developed during twenty-five years in the manufacture of steam turbines, speed reducing gears, and centrifugal pumps and blowers. The De Laval Shops are equipped to produce high grade work, and no other kind of work is attempted. High grade, accurate work, and cheap, rough work cannot be combined successfully under one management and under one roof, as workmen capable of producing high grade precision work cannot work as rapidly as is necessary for cheap production, while, on the other hand, men trained to produce cheap work rapidly are unfit for precision work. The gage and jig equipment necessary to precision production represents a greater investment than the entire mechanical equipment of many machine shops, but it is only with adequate tool equipment that the desired character of work can be produced, and that parts can be manufactured to such accurate dimensions that they will be uniform and interchangeable. High grade workmanship, good materials and interchangeability are not always necessary for the initial mechanical operation of a machine, but they are essential to long life and to the maintenance of efficiency.

The system of production and control in the De Laval Works includes skilled engineering supervision, careful purchase and rigid inspection of materials, high quality and accurate workmanship, proper testing of completed machines and the efficient operation of all departments.

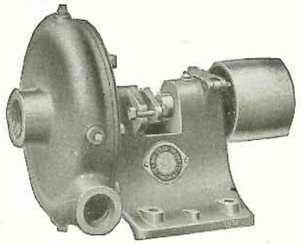
All apparatus is standardized. All parts of a machine are made to limit gages by the machinist and are then tested to duplicate gages by an inspector, and no part falling outside of the prescribed limits is accepted. Accurate dimensions of repair parts are assured. The individual inspector is held responsible for each piece that passes through his hands, and is required to stamp on it a symbol number to identify it and a further mark to certify his inspection. This method of marking each piece with a symbol number is of material value to the user, as, by simply specifying the symbol number in ordering, an exact duplicate of the part can be obtained at any time.

Careless manufacturing methods often cause expense and great annoyance to purchasers later on that offset any saving in first cost due to such methods.

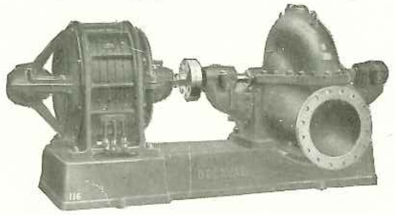
Products of the De Laval Steam Turbine Company:

Steam Turbines, Double Helical Speed Reducing Gears, Worm Reduction Gears, Turbo Generators, Centrifugal Blowers and Compressors, Single and Multistage Centrifugal Pumps, Water Turbines, Flexible Couplings and Special Centrifugal Machinery.

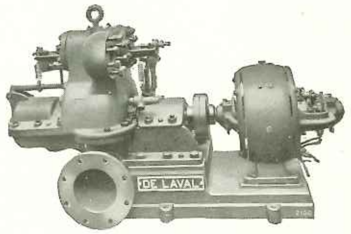
Ask for Special Catalogs



Small centrifugal pump



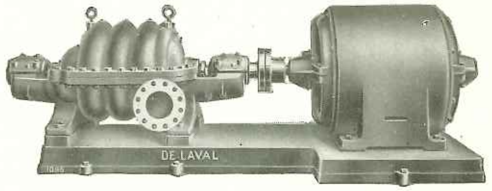
Single stage centrifugal pump driven by induction motor



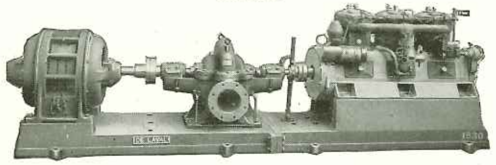
Steam turbine directly connected to small direct current generator

Multistage compressor driven by multistage turbine

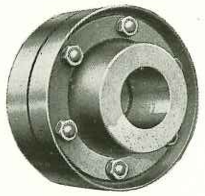
Worm reduction gear



Four stage centrifugal pump driven by electric motor

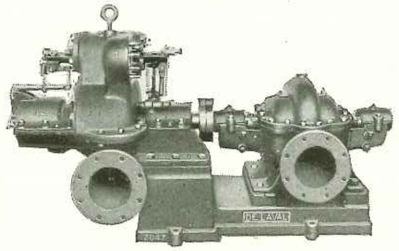


Centrifugal pump driven by gasoline engine and electric motor

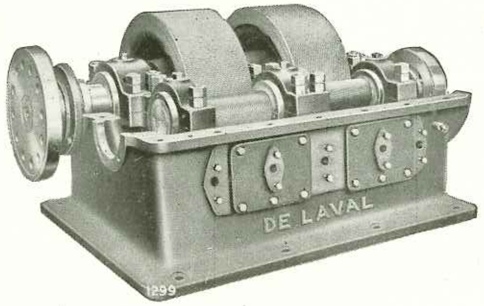


Flexible coupling

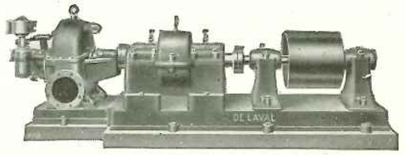
Geared steam turbine driving alternating current generator



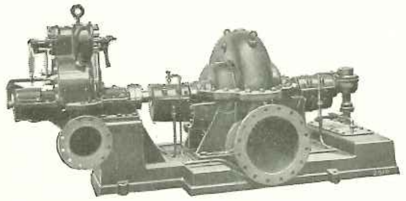
Steam turbine driven single stage pump



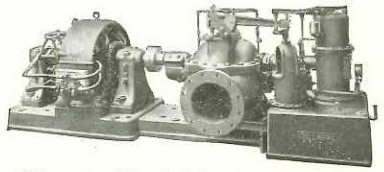
Double helical speed reducing gears with cover removed



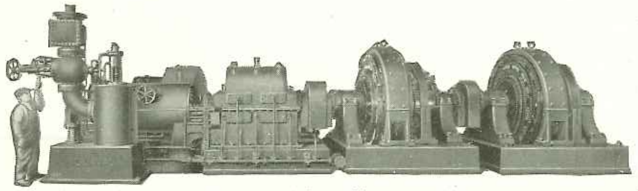
Geared steam turbine with pulley for belt transmission



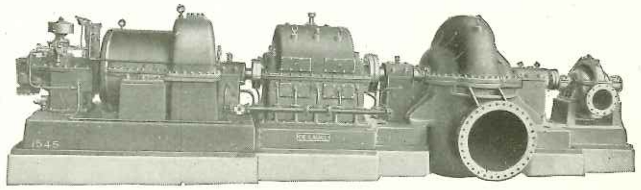
Turbine driven gas blower



Water turbine driving DC generator



Geared steam turbine driving direct current generators



Steam turbine driven centrifugal pump for large water works plant

GEO. H. GIBSON CO.